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(पहला पुनरीक्षण)

Storage of Cereals and Pulses

Part 3 Control of Attack by Pests

(First Revision)

ICS 67.060

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FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Foodgrains, Allied Products and Other Agricultural Produce Sectional Committee had been approved by the Food and Agriculture Division Council.

This Indian Standard has been published in three parts. The other parts in this series are:

Part 1 General consideration in keeping cereals

Part 2 Essential requirements

This standard was first published in 1986, taking guidance from the ISO 6322-3 : 1981 'Storage of cereals and pulses — Part 3: Control of attack by vertebrate and invertebrate animals' issued by the International Organization for Standardization. This revision has been undertaken taking considerable assistance from ISO 6322-3 : 1989 'Storage of cereals and pulses — Part 3: Control of attack by pests'.

In the formulation of this standard, due consideration has been given to the provisions of the *Food Safety and Standards Act*, 2006 and the *Rules* and *Regulations* framed thereunder and the *Legal Metrology (Packaged Commodities) Rules*, 2011. However, this standard is subject to the restrictions imposed under these, wherever applicable.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STORAGE OF CEREALS AND PULSES

PART 3 CONTROL OF ATTACK BY PESTS

(First Revision)

1 SCOPE

1.1 This standard gives guidance on the means of controlling attack by pests on cereals and pulses in storage.

1.2 Other aspects of storage of cereals and pulses are dealt with in Part 1 and 2 of this standard.

2 VERTEBRATE PESTS

2.1 General

2.1.1 The ability of birds, rats, mice and other rodents to feed on grain is not limited by the quality or condition of the grain but only by its accessibility.

2.1.2 The effects of attack by birds, rats, mice and other rodents are contamination, spillage, loss in mass and lowering of quality. Contamination may, for example, prevent wheat from being used for flour milling because of excessive count of rodent hairs in the finished flour.

2.1.3 Attention to hygiene and proofing of stores against access are the principal preventive measures, although anticoagulant baits (such as warfarin) may also be used for routine control of rats and mice. The use of an acute poison may be necessary if resistance to anticoagulants appears in rat or mouse populations.

2.1.4 Birds should be excluded from grain stores by stringent bird-proofing by fixing wire gauge steel frames on doors, windows, ventilators and other exits. Outside the stores, birds may be scared away or repelled by suitable means.

2.2 Control

2.2.1 Rats and mice may be controlled by trapping, or by the use of a bait incorporating a poison which acts within a few minutes of ingestion (acute poison) or, by one which acts over a period (chronic poison) or by fumigation with gas. Fumigation is generally used as a part of an integrated control system, as it normally gives no residual protection.

2.2.2 Fumigation against rodents is normally performed at lower dosage rates and for shorter periods of exposure than those required rodents. Methods involving fumigation or the use of acute poisons should be carried out only by properly trained persons, as specified by governmental regulations.

3 INVERTEBRATE PESTS

3.1 General

3.1.1 Attack by insects and mites is influenced by the accessibility of cereals and pulses and also by the type and condition of the grain.

3.1.2 Attack may not only lead to loss in mass and to contamination, but may alter the condition and quality of the grain.

3.1.3 Infestation of grain both by true storage pests and by field crop pests, for example *Thysanoptera* (thrips) or Lepidoptera [for example *Apamea sordens* (Hufn) (rustic shoulder knot moth)], may result in the contamination of milled products with insect fragments.

3.2 Onset of Infestation

3.2.1 ***Pulses***

3.2.1.1 Pulses are liable to be attacked during growth by various moths and pulse beetles (*Lepidoptera and Coleoptera)* [for example*, Bruchus pisorum* (L.) (pea beetle)] which lay eggs on the developing pods. The larvae penetrate into the seeds and continue to develop in the dry seeds after harvest, adult pulse beetles eventually emerging and flying to the fields to start the cycle again. Some species [for example, *Callosobruchus maculatus* (F.) (cow pea beetle) and *Acanthoscelides obtectue* (Say.) (dried bean beetle)] are capable of continuing to reproduce on the dry peas and beans. Seeds containing pupae or adults ready to emerge can be recognized by the thin outer layer of the seed coat, or 'window', covering the end of the exit tunnel. Seeds from which beetles have emerged have clean round holes. Tests for infestation of pulses are described in IS 6261.

3.2.1.2 The storage of pulses should therefore be organized on the assumption that they are already infested when taken into store. The risk depends on local circumstances (climate, field control methods, etc), being greatest in the tropics, where conditions favour survival and continuous rapid development of pests.

3.2.2 ***Cereals***

3.2.2.1 Field infestation of cereals by storage insects occurs mainly in the tropics and sub-tropics but also in the warmer parts of temperate regions. It is normally

caused by insects flying out from storage buildings to lay eggs on ripening crops. Some improved varieties of hybrid maize with short sheath leaves surrounding the cob are particularly liable to such infestation. Insects causing such infestation are mainly *Sitotroga cerealella* (Oliv.) (Angoumois grain moth) and Sitophilus *zea-mais (Motsch*) (greater maize weevil).

3.2.2.2 In most temperate climates, infestation by storage insects usually starts after the harvested crop has been placed in store, but may commence immediately if the combine harvester or sacks harbor insect pests.

3.2.2.3 Storage of cereals in areas where field infestation by storage insects may occur should take this risk into account. Storage of cereals in most temperate areas can be organized on the basis that grain from the field is free from infestation, except for certain species of mites.

3.2.2.4 Some species of mites carried with grain from the field can continue to breed in store (for example, *Tyrophagus longior Gerv*.) but, more commonly, the dominant mites are true storage species [for example, *Acarus siro* L. (flour mite)].

3.2.2.5 Mites are particularly a grave problem wherever grains are stored under high atmospheric relative humidities or their moisture contents exceeds 15 percent (m/m) , even when the temperatures are too low for insect development.

3.3 Factors Affecting Insect and Mite Development

3.3.1 A few species of insects [for example, Sitophilus granaries (L.) (grain weevil)] can attack completely sound grain, but abrasion of the seed coat, breakage during harvesting and movement and admixtures of cereal dust, facilitate attack by many other species of insects and mites [for example, *Oryzaephilus surinamensis* (L.) (saw toothed grain beetle), *Acarus siro* L. (flour mite)].

3.3.2 The insects and mites found in stored cereals include those which tunnel in the endosperm [for example, *Sitophilus granaries* (L.) (grain weevil), *Sitophilus oryzae* (L.) (rice weevil)], those which consume the germ [for example, *Cryptolestes Ferrugineus* (Steph.) (rust red grain beetle), *Plodia interpunctella* (Hubn.) (Indian meal moth) and *Acraus siro* L. (flour mite)], those which attack broken pieces [for example *Glycyphagus destructor* (Schr.) (forage mite)], those which live on moulds [for example, fungus beetles (Cryptophagidae and Mycetophagidae)], those which are parasites or predators on other insects and mites [for example, Braconidae and Cheyletidae) and those which are scavengers on dead bodies of other insects (for example, Dermestidae). Many species are capable of performing more than one role [for example, *Tenebroides mauritanicus* (L.) (Cadelle beetle), a predator and an occasional feeder on germ].

3.3.3 The principal factors which affect the development and activity of insect and mite pests are:

a) temperature,
b) moisture content of the grain,
c) relative humidity of the immediate atmosphere, and
d) nature of the grain.

3.3.3.1 Most insect pests of store grain cannot complete the full development from egg to adult, mating and further egg production at temperatures below 10°C or greater than 35°C. The minimum temperature required for the multiplication of most of the serious insect pests is about 15°C and the lower end of the optimum range is at least 20°C. For most mites, the limits and optima are generally 5°C lower.

3.3.3.2 The moisture content of grain affects insects and mites directly since, they absorb water with their food and indirectly through controlling the relative humidity of the inter-granular air. For each development cannot take place or which is lethal. Grain of less than 9 percent (m/m) moisture content (equilibrium relative humidity of 30 percent) is generally secure form insect or mite attack, although *Trogoderma granarium* Everts (khapra beetle) can breed at a moisture content of 2 percent (m/m).

3.3.3.3 For each species, there is a combination of temperature and humidity at which populations increase most rapidly. This means that different species tend to occur in those parts of India where the climate is most suitable for them.

3.3.3.4 A summary of these conditions for the most common species of grain pests is given in Appendix A.

3.4 Heating of Grain Caused by Insects and Mites

3.4.1 Large bulks or bagged stacks of cereals and pulses tend to stabilize the conditions of temperature and humidity within them. It is these conditions, in particular, which directly affect the insects, and not the diurnal fluctuations in the free space of the store. Local variations in the temperature and moisture contents of bulks are exploited by insects and mites which tend, by random movement, to find their way to favourable breeding places. If conditions here are above the minima shown in Appendix A, the insects will breed. As they develop they produce heat which may not disperse as rapidly as it is produced. Temperature rises and insect development accelerates. Eventually the temperature rises to an unfavorable level, usually not above 42°C, and those insects which can move outwards do so; those which cannot (for example, larvae within grains) eventually die. The living insects finally concentrate at the surface.

3.4.2 Temperature gradients are established in the bulk, and moisture moves from the hot interior to the cooler periphery. If the temperature at the surface is below the dew point of the moist air from the interior, condensation will take place and the grain may eventually sprout. Moisture content and equilibrium relative humidity may be raised locally to a point at which the growth of moulds is initiated. Thus, in grain nominally safe for definite storage, 'dry grain heating', initiated by insects, may change to 'damp grain heating' caused by micro-organisms. The temperature in 'damp grain heating' seldom rises above 62°C and usually remains at about 52°C.

3.5 Prevention and Control of Insect and Mite Infestation

3.5.1 *Prevention*

3.5.1.1 Attack may be prevented by denying access to insects and mites, by maintaining an environment unfavorable for breeding, or by applying a protective treatment to the grain for seed purposes only. The principal techniques for prevention are hygiene, that is the removal of all unwanted grain and dust in which insects and mites can breed, treatment of empty location, and control of the environment, by such means as:

a) Keeping grain below the temperature or the humidity, necessary for increase in pest numbers (for example, drying, aerated storage, and refrigerated storage);
b) Hermetic or inert-atmosphere storage or an artificially generated controlled atmosphere; and
c) Enclosing pest-free grain in insect-resistant containers.

3.5.2 *Control*

3.5.2.0 Control may include killing or removing insects and mites:

a) in empty storage buildings,
b) in empty transport vehicles,
c) in containers (including sacks) before they are filled with grain, and
d) in the grain itself.

3.5.2.1 *Mechanical and physical methods*

Grain may be screened to remove free living insects and mites; it can be placed in airtight storage, in which insects are killed when they reduce the oxygen content in the atmosphere to below 2 percent.

3.5.2.2 *Biological methods*

There are very few circumstances in which biological control (that is, the use of predators, parasites or pathogens) is likely to be effective in the control of cereal pests, because the levels of stabilized populations are normally too high to be tolerated. The bacterium *Bacillus thuringiensis* may be used commercially for the control of moths in stored wheat, maize, sorghum grain, rough rice and soya beans.

3.5.2.3 *Chemical methods*

Chemical are used in two main forms, contact insecticides and fumigants.

a) *Contact insecticides* — Residual contact insecticides and acaricides applied as dusts, oil-in-water emulsions or water dispersible sprays, aerosols or smokes render the surfaces of empty stores, transport vehicles, ships, cargo containers and conveying equipment toxic to insects and mites. When the insects and mites cross these surfaces they pick up sufficient toxic material to kill them before they reach the commodity to be protected. This technique is effective against crawling insects and mites. The period for which the insecticide persists is dependent on the nature of the surface, temperature, moisture content of the air and extent of exposure of light. Flying insects may be killed by the use of aerosols or smokes whilst in flight, or when they alight on a treated surface; flying insects and those on the surface of commodities may also be controlled by volatile insecticides intermediate in properties between contact insecticides and fumigants.
b) *Fumigants* — Control of pest populations deep in the structure of buildings or vehicles, in empty sacks and in the grain itself, whether in bags or bulk, can be achieved only by fumigants, which act as passes, even though they may be applied as solids or liquids, and which normally have no residual effect on insects or mites after the fumigant has dispersed. Fumigant gases are generally toxic to man and should only be used by properly trained persons, who know the dangers and the necessary safeguards.
c) *Pesticide Residues* — The recommendations of the *Food Safety and Standards Authority of India* (FSSAI) regarding limits for residues in food are taken into account in such regulations.

APPENDIX A

(*Clauses* 3.3.3.4 *and* 3.4.1)

LIMITING AND OPTIMUM CONDITIONS FOR INCREASE OF POPULATIONS OF CERTAIN INSECT AND MITE PESTS OF STORED PULSES AND CEREALS

SPECIES	COMMON NAME	MINIMUM		OPTIMUM		MAXIMUM RATE OF MULTIPLICATION PER MONTH	SUSCEPTIBILOITY OF PRODUCTS TO ATTACK					
		Temperature, °C	Relative Humidity, Percent	Temperature, °C	Relative Humidity, Percent Minimum		C	C*	C**	c	P	p
Acanthoscelides obtectus (Say.)	Dried bean beetle	17	30	27 to 31	65	25					*	
Acarus siro L.	Flour mite	2.5	65	21 to 27	80	2 500		*		*	*	*
Callosobruchus chinesis (L.)	Cowpea beetle	19	30	28 to 32	60	30					*	
Callosobruchus maculatus (F.)	Cowpea beetle	22	30	30 to 35	50	50					*	
Corcyra cephalonica (Staint.)	Rice moth	18	30	28 to 32	30	10		*		*		
Cryptolestes Ferrugineus (Steph.)	Rust red grain beetle	23	10	32 to 35	65	60		*		*		
Cryptolestes pusillus (Schon.)	Flat grain beetle	22	60	28 to 33	70	10		*		*		
Ephestia cautella (Wlk.)	Tropical warehouse moth	17	25	28 to 32	60	50		*		*		
Ephestia elutella (Hubn.)	Warehouse moth	10	30	25	70	15		*		*		*
Ehestia kuehniella Zeller	Mediterranean flour moth	10	1	24 to 27	65	50		*		*		
Lasioderma serricorne (F.)	Cigarette beetle	22	30	32 to 35	55	20				*	*	
Laheticus oryzae Waterh.	Long headed flour beetle	26	30	33 to 37	—	10			*	*		
Oryzaephilus surinamensis (L.)	Saw toothed grain beetle	21	10	31 to 34	65	50		*		*		
Plodia interpunctella (Hubn.)	Indian meal moth	18	40	28 to 32	—	30		*		*		
Ptinus tectus Boield.	Australian spider beetle	10	50	23 to 25	70	4		*		*		*
Rhizopertha dominica (F.)	Lesser grain borer	23	30	32 to 35	50	20	*			*		

SPECIES	COMMON NAME	MINIMUM		OPTIMUM		MAXIMUM RATE OF MULTIPLICATION PER MONTH	SUSCEPTIBILOITY OF PRODUCTS TO ATTACK					
		Temperature, °C	Relative Humidity, Percent	Temperature, °C	Relative Humidity, Percent Minimum		C	C*	C**	c	P	p
Sitophilus granarius (L.)	Grain weevil	15	50	26 to 30	70	15	*					
Sitophilus oryzae (L.)	Rice weevil	17	60	27 to 31	70	25	*					
Sitotroga cerealella (Oliv.)	Angoumois grain moth	16	30	26 to 30	—	50	*					
Tribolium castaneum (Herbst.)	Rust red flour beetle	22	1	32 to 35	65	70			*	*		*
Tribolium confusum Duv.	Confused flour beetle	21	1	30 to 33	50	60			*	*		*
Trogoderma granrium Everts.	Khapra beetle	24	1	33 to 37	45	12.5	*			*	*	*
Zabrotes subfasciatus (Boh.)		22	30	29 to 33	50	20					*	

C — Whole undamaged cereals,

C* — Germ of cereals,

C** — Cereal grain already damaged mechanically or by other insects,

c — Cereal products,

P— Whole pulses,

p — Pulse products.

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